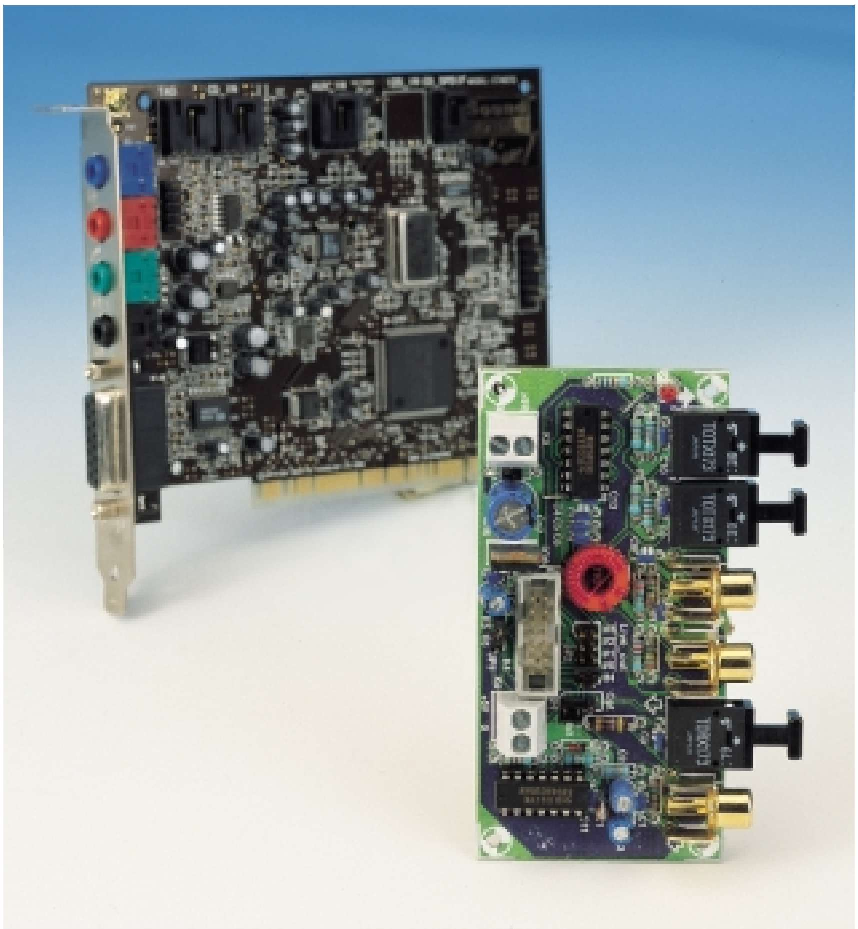
digital inputs and outputs

for the SoundBlaster® Live!Value card

Without any question, the most popular sound card for the PC is currently the SoundBlaster Live!, together with its less expensive cousin Live!Value. The main difference between the two is that the Live! version has an additional plug-in card with digital inputs and outputs. The design presented here gives owners of a Live!Value card the opportunity to equip it with the necessary optical and coaxial digital inputs and outputs.

Design by T. Giesberts



Nowadays, a modern PC cannot do without sound. Most computers thus contain a sound card, which offers a large number of features. Until recently, such cards had only analogue inputs and outputs, but presently there are also models available with connectors that allow digital audio signals to be read in or sent out. This makes it much more convenient to, for example, read in a digital signal from a DAT or MD recorder, edit it on the PC and then play it back or record it on a CD-R, all without any intermediate analogue stage.

The SoundBlaster Live! is one of the most widely distributed sound cards with digital audio I/O. The digital I/O portion is contained on a separate plug-in card with its own bracket, on which the digital connectors are mounted. The 'stripped-down' version of the Live! card set, the Live!Value, is naturally much more attractively priced, but this comes at the expense of the digital I/O card.

Since the Live!Value card has an expansion connector that houses all the necessary signals, it seemed an excel-

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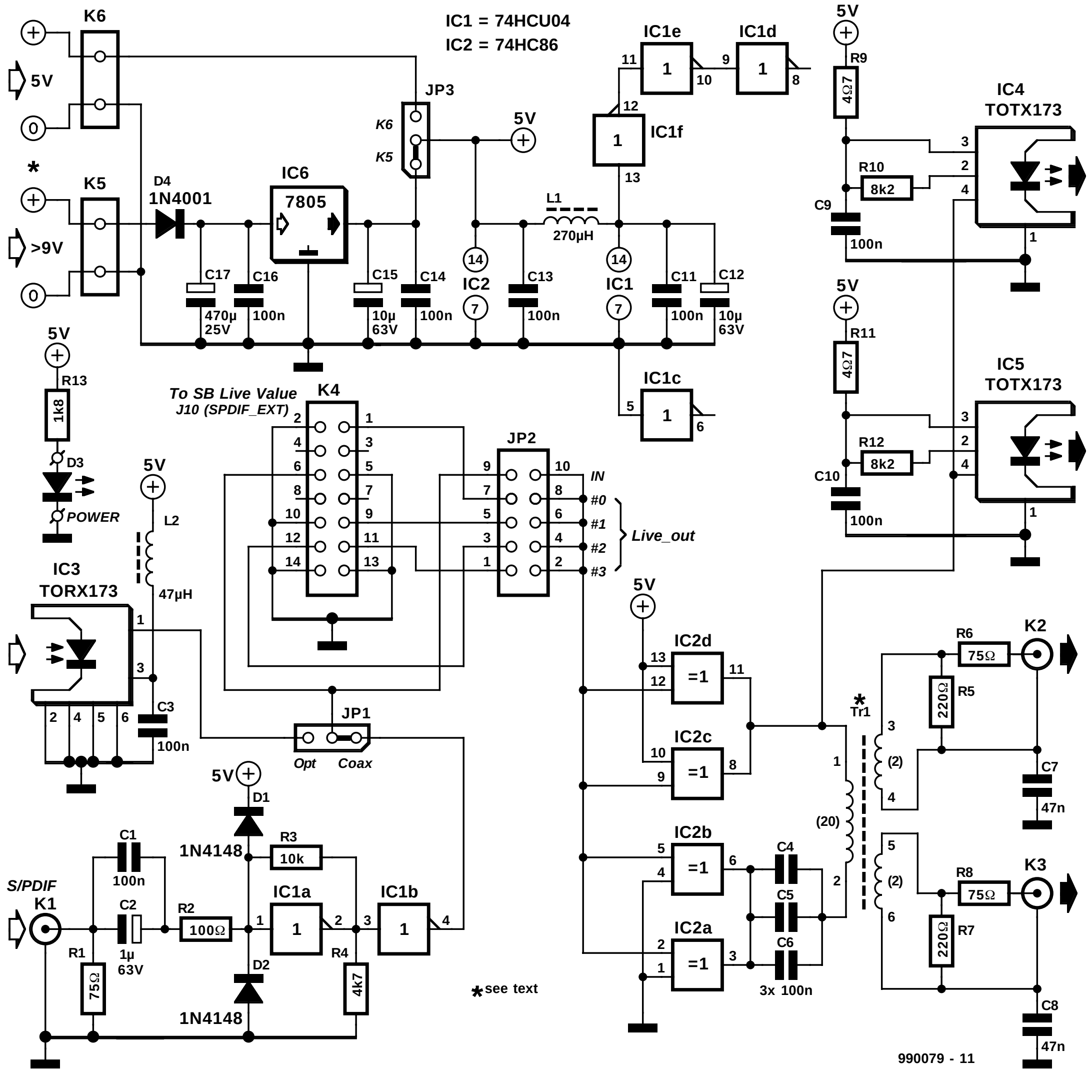

Figure 1. The schematic diagram of the expansion card circuit, which mainly consists of input and output connectors. There are in total two digital inputs and four digital outputs.

lent idea to design a DIY card with digital audio connectors that can simply be connected to the expansion connector via a length of flat cable. In this way, owners of a Live!Value card can easily upgrade it.

To make everything perfectly clear, this design has been developed to work with the standard version of the Live!Value card, which has a 12-pin S/PDIF expansion connector (refer to your owner's manual). At the moment, there is a new version available, called the Live!Value 1024, which has a different type of expansion connector and which already has a coaxial digital output as a standard feature.

MINIMAL HARDWARE

Connector J10 on the Live!Value card is a set of 12 pins arranged in a double row at the edge of the sound card, and labelled SPDIF_EXT (see **Table 1**). This connector contains one S/PDIF input and four S/PDIF outputs. One pin also provides +5 V, passed through from the PC supply. No specifications are available for this pin. For this reason, we have assumed that the digital expansion card will be powered via a direct connection to the internal +5 V supply line of the PC or — if the card is used external to the PC — via a mains adapter.

Since all required signals are present at the S/PDIF expansion connector, it is only necessary to add a few connectors and buffers. If you look at the schematic diagram in **Figure 1**, you will see that the active components form a relatively small part of the total.

Two digital inputs are present, one of which is optical (IC3, a standard TOSLINK receiver) and the other coaxial (K1, for an S/PDIF input signal of 0.5 V_{pp} into 75 Ω). The active input connector can be selected via jumper JP1.

A proven circuit, using two inverters of a 74HCU04 (IC1), is used to process the incoming S/PDIF signal from the coaxial connector. IC1a is used as an analogue amplifier. The incoming signal is first amplified by a factor of seven (without clipping). The average level of the amplified signal thus lies in the region of the switching point of the second inverter. IC1b again amplifies the signal to produce clean CMOS logic levels. R4 holds the input of IC1b a bit below the switching point in the

Table 1. Pinout specifications of the 12-pin S/PDIF expansion connector (J10) on the SB Live!Value card.

Pin	Name	Description
1	SPDIFO#0	S/PDIF-0-output
2	GND	ground
3	KEY	
4	VCC	supply (+5 V)
5	GND	ground
6	SPDIF_IN	S/PDIF-input
7	-	not connected
8	-	not connected
9	SPDIFO#1	S/PDIF-1 output
10	GND	ground
11	SPDIFO#2	S/PDIF-2 output
12	SPDIFO#3	S/PDIF-3 output

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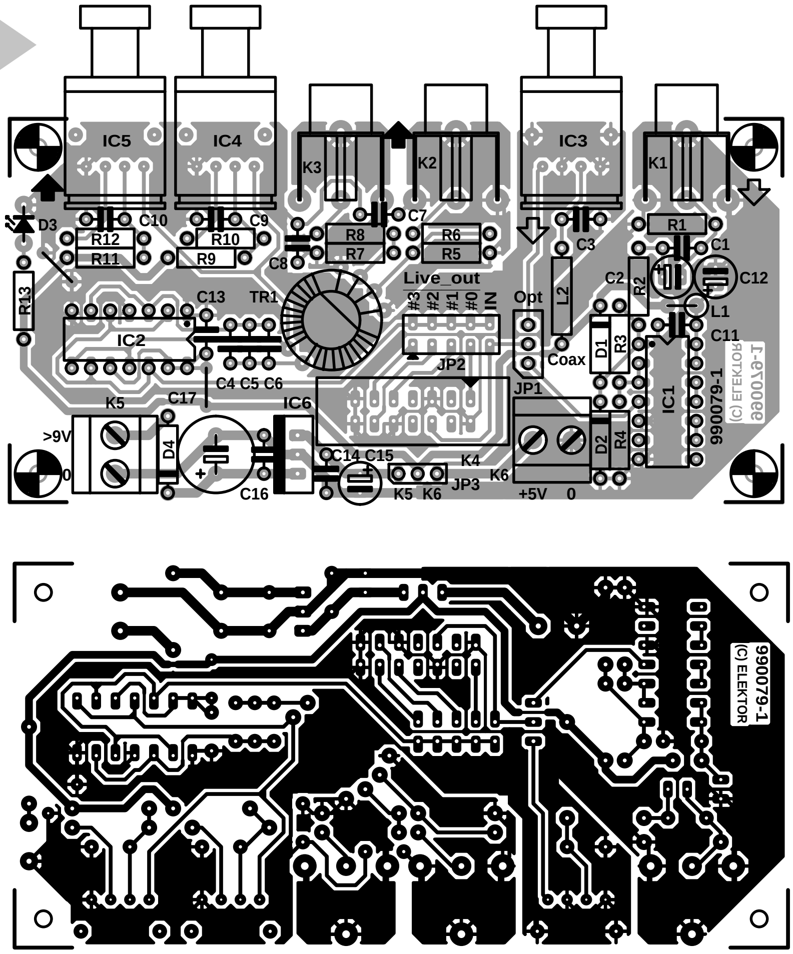


Figure 2. The printed circuit board layout shown here accommodates all of the connectors shown in the schematic diagram, so that the card can readily be fitted into a separate enclosure or on the rear side of a 5¼” panel insert.

COMPONENTS LIST

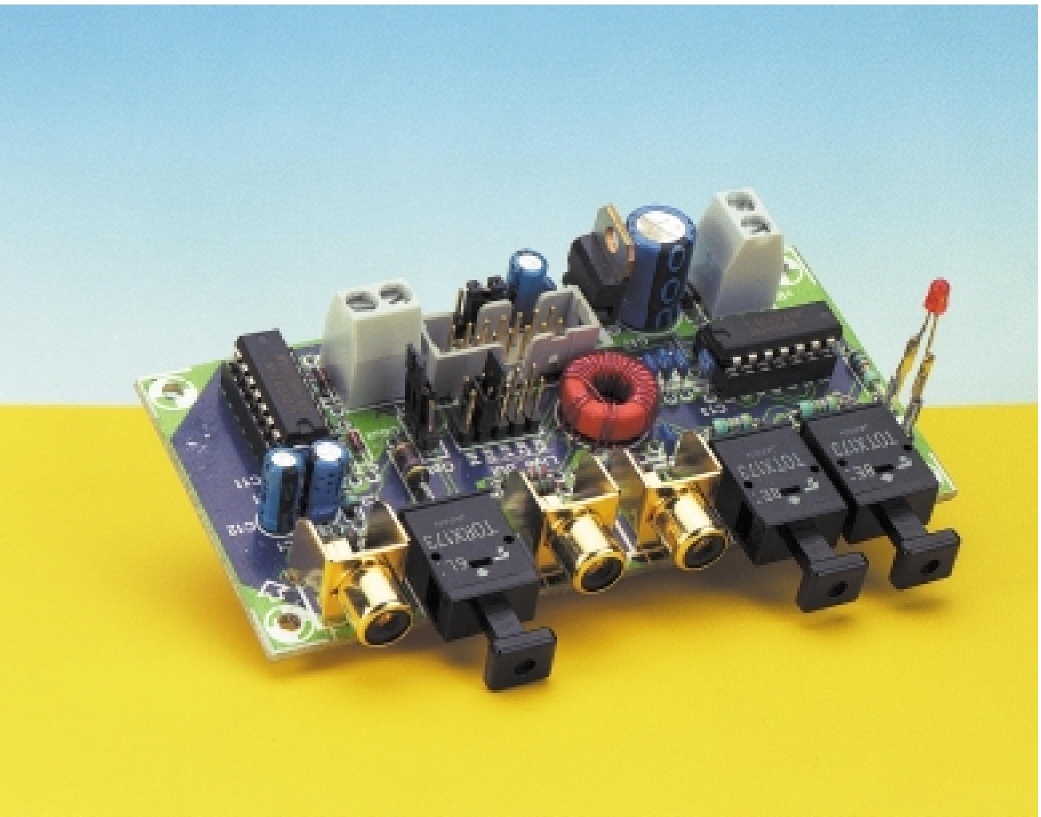
Resistors:
R1,R6,R8 = 75Ω
R2 = 100Ω
R3 = 10kΩ
R4 = 4kΩ7
R5,R7 = 220Ω
R9,R11 = 4Ω7
R10,R12 = 8kΩ2
R13 = 1kΩ8

Capacitors:
C1,C3-C6,C9,C10,C11,C13,C14,C16 = 100nF ceramic, pitch 5mm
C2 = 1μF 63V radial
C7,C8 = 47nF ceramic
C12,C15 = 10μF 63V radial
C17 = 470μF 25V radial

Inductors:
L1 = 270μF
L2 = 47μF

Semiconductors:
D1,D2 = 1N4148
D3 = high efficiency LED
D4 = 1N4001
IC1 = 74HCU04
IC2 = 74HC86
IC3 = TORX173 (Toshiba)
IC4,IC5 = TOTX173 (Toshiba)
IC6 = 7805

Miscellaneous:
JP1,JP3 = 3-way pinheader with jumper
JP2 = 10-way double-row pinheader with 1 jumper
K1,K2,K3 = cinch socket, PCB mount (Monacor/Monarch T-709G)
K4 = 14-way boxheader
K5,K6 = 2-way PCB terminal block, pitch 5mm
Tr1 = ferrite core transformer, Philips TN13/7,5/5-3E25, primary 20 turns, secondary 2 x 2 turns. Wire: 0.5 mm dia. (24SWG) enamelled copper.
PCB, order code 990079-1 (see Readers Services page)



absence of an input signal, so that interference signals do not appear at the output of IC1b due to input noise and the like. R1, D2 and D2 protect IC1 against incorrect input signals.

The middle pin of the input selection jumper JP1 is directly connected to the header K4, which provides the link to the expansion connector of the sound card. A 14-pin box header was chosen for K4, since this is a standard component. Pins 1 through 12 match the connections on the sound card. Pins 13 and 14 are connected to earth on the expansion card and can be used for screening if desired.

All four S/PDIF outputs present at the expansion connector of the sound card are passed through to the expansion card. The jumper block JP2 selects one of the four digital outputs of the Live!Value card to be connected to the outputs of the expansion card. In prac-

Transformer trickery

Driving the output transformer symmetrically, as practised in this design, is rather unusual. This is reason enough to provide a few explanatory remarks.
The first reason for driving TR1 symmetrically is that the amplitude of the resulting primary signal (10 V_{pp}) allows the turns ratio between the primary and secondary windings to be increased to 10:1. A coaxial cable must be terminated at each end in its characteristic impedance (75 Ω in this case). This suppresses signal reflections that would otherwise occur. The output signal amplitude at the transformer secondary side must thus be 1 V_{pp} to provide a voltage of 0.5 V_{pp} across 75 Ω. The large turns ratio yields a lower output impedance as well as increased bandwidth, due to the better coupling factor that results from the fact that the primary winding covers most of the core.
A second reason for driving the transformer symmetrically is that the primary winding can then be split into two equal halves if a toroidal core is used. The primary and secondary connections thus lie at opposite sides of the core, and the connection between the two halves of the primary winding is essentially a virtual earth point, which further reduces crosstalk between the primary and secondary windings. This improves the electrical isolation in the RF region.
The outputs are already damped by R5 and R7 to suppress overshoots.
Resistors R6 and R8 essentially determine the output impedance (75 Ω). Capacitors C7 and C8 earth the cable screens for RF. Capacitors C4 through C6 are connected in parallel to improve the quality of the resulting capacitor by minimizing the total effective series resistance. These coupling capacitors are needed to prevent the outputs of the buffer (IC2) from being shorted together via the transformer when no signal is present.

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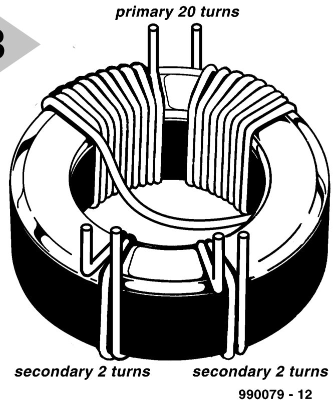


Figure 3. This drawing shows how the output transformer must be wound, with a 20-turn primary and two 2-turn secondaries.

tice, it turns out that the output signal is normally found on the SPDIF#0 output.

The option of selecting the input signal (IN) has been added as an extra feature. With this selection, the input of the expansion card is connected through to its output. This can be useful for checking the inputs and outputs and/or the input and output signals. It also allows the circuit to be used as optical to coaxial converter (or the other way around), or as an S/PDIF splitter.

The signal from jumper JP2 is passed to the inputs of IC2. Two gates of this quad XOR IC are connected in parallel as a non-inverting buffer (IC2a and IC2b). The other two (IC2c and IC2d) are connected in parallel as an inverting buffer. The latter pair drives the two TOSLINK output modules (IC4 and IC5). This means that when the circuit is used as a converter/splitter (jumper JP2 set to 'IN'), the LEDs in the output modules will be off in the absence of an input signal. The design of the circuitry connected to the TOSLINK modules IC3, IC4 and IC5 is standard, and consists mainly of supply-decoupling components.

The home-made output transformer is driven symmetrically by the two pairs of XOR gates. The reason for using XOR gates is that the two configurations have equal propagation delay times, which results in cleanly symmetric outputs. The transformer provides galvanic isolation between the output connectors (K2 and K3) and the rest of the circuit. This helps to prevent earth loops and other possible sources of interference.

As already mentioned, there are two options for the power supply. If the card is fitted in the PC (behind a 5¼" panel insert, for instance), K6 can be connected directly to the +5 V supply line of the PC by attaching a 'Y' adapter to one of the internal power supply connectors. In this case, put jumper JP3 into the 'K6' position. The other option, with JP3 in the 'K5' position, is intended for when the card is used external to the PC. In this case a mains adapter can be used to supply power. For convenience, a standard 5 V regulator is already present on the card, together with a diode and filter capacitors, so that just a small transformer (9 V/1.5 A) would be sufficient. D4 is intended primarily as protection against wrong-polarity connections. A mains adapter with an unstabilized output of 9 V or more can thus be used as the power source.

CONSTRUCTION

Assembling the circuit board, shown in **Figure 2**, in not a difficult task. All Cinch sockets, TOSLINK modules and other connectors can be soldered to the board straight away. Sockets may be used for the two digital ICs, while the remainder of the passive and active components can be soldered directly to the circuit board. If you take another good look at the photo, you can quickly and clearly see how everything should be fitted. The only difficult component is the transformer, which you will have to wind yourself. You will need half a metre of 0.5-mm diameter enamelled copper wire and a 13 × 5.5-mm toroidal core (see the components list for the part number). Put a primary winding of 20 turns on the core, and two secondary windings of 2 turns each. The drawing shown in **Figure 3** clearly illustrates how the windings should be located on the core.

Depending on where you decide to use the card, you can use a pair of brackets to attach it to the rear of a 5¼"panel insert in which you have made the necessary openings, or you can fit it into a separate enclosure. If the card is fitted inside the PC, it is connected to the Live!Value card with a length of 14-lead flat cable fitted with a 14-way header at each end. When connecting this cable to connector J10 of the sound card, make sure that pin 1 of the cable header is connected to pin 1 of J10.

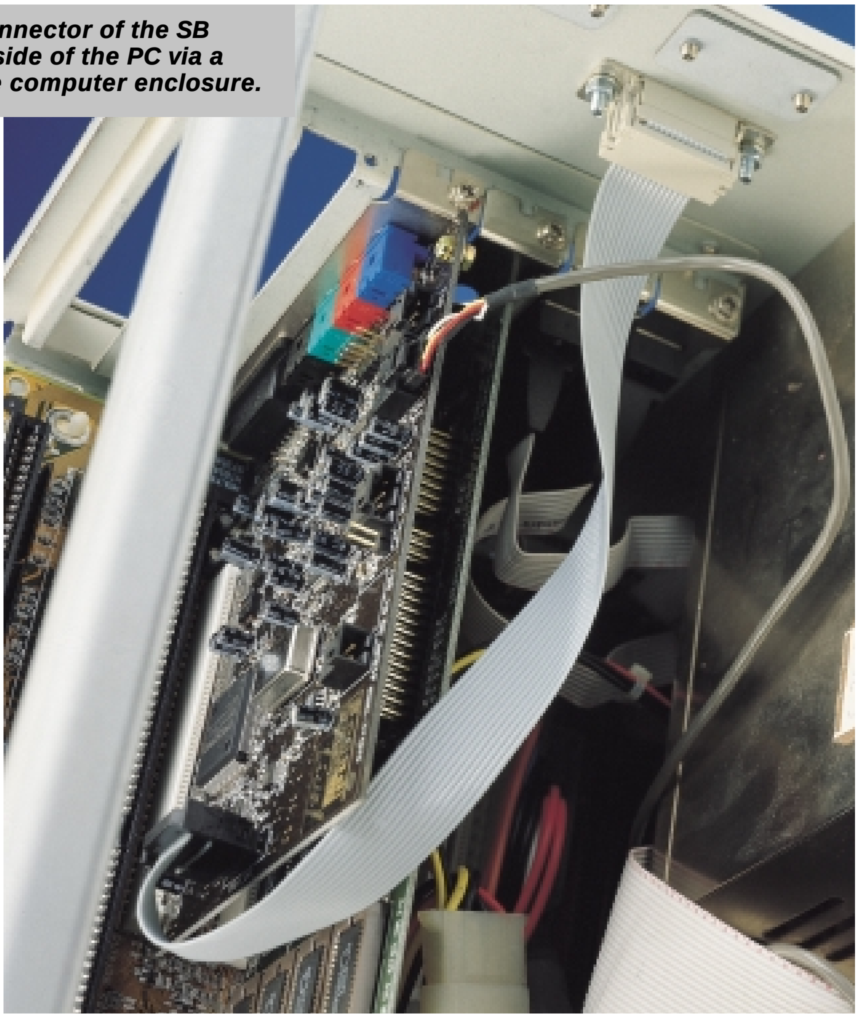
If the card is mounted external to the PC in its own enclosure, the most convenient solution is to use the flat-cable version of Sub-D connectors. If the same connections are made to the Sub-D connectors at both ends (PC and expansion card), all you have to do is to make sure that pin 1 of the one connector is always connected to pin 1 of the other connector.

Finally, a few general remarks.

You can make the selection of the input connector (between optical and coaxial) variable by connecting the pins of JP1 to a small single-pole, double-throw switch (slide, alternate-action or toggle). Connect the common contact to the centre pin of JP1. Keep the length of the interconnecting wiring to an absolute minimum.

The current consumption of the circuit varies between 60 and 80mA, depending on whether the optical or coaxial input signal is used. If you

Figure 4. The leads from the expansion connector of the SB Live!Value card can be brought to the outside of the PC via a Sub-D connector fitted into a cutout in the computer enclosure.



want to take the risk of powering the expansion card from the +5V supply of the sound card, you can connect a wire between pin 4 of K4 and the middle pin of the header for JP3. In this case jumper JP3 must not be installed, and the on-board supply components (K4, K6, D4, C14-C17 and IC6) can be omitted.

In conclusion, we would like to remark that driving the additional digital inputs and outputs is only possible with recent versions of the program/driver software (Live!Wire version 2.0 or higher). This is available by download from the special SB Live! web site *http://www.sblive.com*, as well as from other sources.

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Note:
Owners of the newer SB Live!Value 1024 card who want to increase the number of digital inputs and outputs can find the input and output specifications of this card at the on-line help site. With this information, you can even experiment with connecting the expansion card described here to the new version of the sound card, which has several inputs on the expansion connector. We would like to hear about the results!